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NRL Report 48

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PROJECT VANGUARD REPORT NO. 10  
PROGRESS THROUGH OCTOBER 15, 1956

[UNCLASSIFIED TITLE]

Project Vanguard Staff

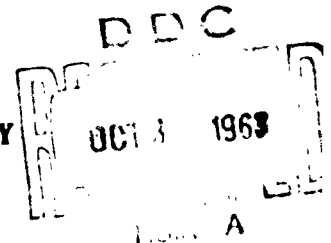
November 4, 1956

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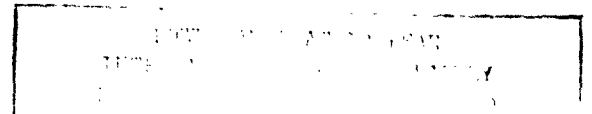
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### **PREVIOUS PROJECT VANGUARD REPORTS**

Project Vanguard Report No. 1, "Plans, Procedures, and Progress" by the Project Vanguard Staff, NRL Report 4700 (Secret), January 13, 1956

Project Vanguard Report No. 2, "Report of Progress" by the Project Vanguard Staff, NRL Report 4717 (Confidential), March 7, 1956

Project Vanguard Report No. 3, "Progress through March 15, 1956" by the Project Vanguard Staff, NRL Report 4728 (Confidential), March 29, 1956

Project Vanguard Report No. 4, "Progress through April 15, 1956" by the Project Vanguard Staff, NRL Report 4728 (Confidential), May 3, 1956

Project Vanguard Report No. 5, "Progress through May 15 1956" by the Project Vanguard Staff, NRL Report 4767 (Confidential), June 2, 1956

Project Vanguard Report No. 6, "Progress through June 15, 1956" by the Project Vanguard Staff, NRL Report 4800 (Confidential), June 28, 1956

Project Vanguard Report No. 7, "Progress through July 15, 1956" by the Project Vanguard Staff, NRL Report 4815 (Confidential), July 27, 1956

Project Vanguard Report No. 8, "Progress through August 15, 1956" by the Project Vanguard Staff, NRL Report 4832 (Confidential), September 5, 1956

Project Vanguard Report No. 9, "Progress through September 15, 1956" by the Project Vanguard Staff, NRL Report 4850 (Confidential), October 4, 1956

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**PROBLEM STATUS**

**This is an interim report; work on the problem is continuing.**

**AUTHORIZATION**

**NRL Problem A02-90**

**Manuscript submitted November 2, 1956**

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⑥ **PROJECT VANGUARD, REPORT NO. 10**  
**~~Progress Through October 15, 1956~~**  
[UNCLASSIFIED TITLE]

PREFACE

This report is intended as a general summary of the progress on Project Vanguard during the indicated period. Hence, minor phases of the work are not discussed to a great extent, and technical detail is kept at a minimum. It is hoped that the information here presented will be of assistance to administrative and liaison personnel in coordinating and planning their activities, and as a guide to the current status of the project. Material of a more technical nature will be published from time to time in separate reports which will be announced in subsequent monthly progress reports.

COORDINATION WITH OTHER SERVICES

**ARMY**

The Army Signal Corps proposal for a satellite acquisition program using the Diana moon-tracking radar\* has been accepted by Project Vanguard. The program for the use of Diana will be executed directly between Vanguard and the Signal Corps Engineering Laboratories.

As outlined in the Army letter of 29 September 1956 (DCS Log Conf ltr LOG/F 60128, 29 Sep 56) and subsequent advisement from the Chief of Engineers, the Army program for establishing, operating, and providing communications for seven prime-Minitrack stations† is as follows:

1. Responsibility: The program for the seven stations will be directed by the Chief of Engineers. Support will be rendered by the Chief Signal Officer, US Army Caribbean, and the CG Third Army.

2. Funding: Funds for the program will be furnished to the Army by Project Vanguard. Initial construction funds have been furnished to the Department of the Army from Department of Defense.

3. Schedule:

Completion of site plans	19 October 56
Completion of advanced design	15 November 56
Awarding of initial construction contract	1 December 56
Beginning of construction	15 December 56
Beneficial occupancy of sites	1 August 57
Completion of equipment installation	1 September 57
Completion of checkout of crews and equipment	1 October 57

4. Status: A design review conference is scheduled for 23 October 1956 at the District Engineer, Jacksonville, Florida, between Project Vanguard and participating Army agencies to review and approve preliminary designs and site layout plans.

5. Communications: A schematic of the communication network for the seven stations is shown in Fig. 1.

**AIR FORCE**

The status of the Vanguard facilities at AFMTC is as follows.

\*P.V.R. No. 9, p. 1

†P.V.R. No. 7, p. 1

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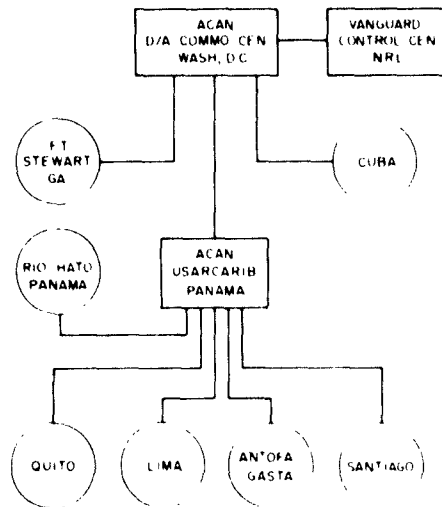


Fig. 1 - Communications plan for Army Prime Minitrack stations

### Launching Complex

The scheduled completion date\* of the launching complex has not been met. At a meeting on 24 August, the Corps of Engineers reported that the complex would be completed on 9 October. On 9 October however, the status of the complex was as follows:

1. There were no roads leading to the complex; the blockhouse was nearly completed and surrounded by ditches.
2. There was no power in the blockhouse.
3. Windows for the blockhouse were scheduled for delivery starting about 1 November and ending about 1 December.
4. Air conditioning equipment was scheduled to leave the manufacturer's plant at the end of October. The most optimistic date for operation of this equipment was 15 November.

The structure which supports the rockets for static and flight firing, which is the responsibility of the Glenn L. Martin Co. and not the Corps of Engineers, is being delivered late by the subcontractor.

The following steps have been taken:

1. NRL and Pan American Airlines engineers have devised a makeshift air conditioning arrangement that will be in operation by 1 November.
2. Arrangements have been made with the AFMTC safety officer to fire with only two glass windows in the blockhouse. The other openings will be covered with steel.
3. Limited temporary power for electronic instrumentation will be available in the blockhouse on 26 October.

As a result of these difficulties, the firing date for TV-0 has slipped by about six days. By means of close coordination, the cooperation of the Air Installations Officer, the Corps of Engineers, and the Jones Construction Co., and the maintenance of a flexible installation program, it is hoped that further slippage can be minimized. Maximum efforts are being made in all areas to hold to the required completion dates. At the present writing, the two critical dates for the launching complex are: (1) the date of installation of the two windows in the blockhouse, and (2) the delivery of the top deck of the firing structure. A static firing can be made approximately 17 days after delivery of the top deck of the firing structure, or about 4 days after the installation of the two windows, whichever is the later date.

\*P. V. R. No. 8, p. 2

### Assembly Hangar

The work in Hangar C appears to be on schedule. The office area is fairly complete, and in the electronic instrumentation laboratory the work benches are installed and wired and most parts and equipment have been checked and put into operation or storage. The nitrogen gas supply required for tests on the TV-0 missile by 17 October, has been installed.

### THE LAUNCHING VEHICLE

The first vehicle of the test series, TV-0, arrived on 1 October at AFMTC along with its support and electronics. The missile and other equipment apparently suffered no damage in transport. Receiving tests on this missile are scheduled to begin on 16 October.

### CONFIGURATION AND DESIGN

Preliminary tests are being made on the double-primer explosive bolts to be used for first-stage separation,\* to determine weight of charge and gage of shielding required to confine parts of the exploded bolt. The redesign of the interstage structure has been released to manufacturing. A flame baffle has been designed to reduce the hazard to vital second-stage components of the high-temperature combustion gases during separation. This baffle will be attached to the first-stage structure immediately aft of the plane of separation, and will divert the flame from the second-stage powerplant compartment. An annular opening in the baffle will provide freedom for full deflection of the second-stage thrust chamber. Explosive latch assemblies will be used to open two doors to vent the interstage compartment; these latches will be triggered at first-stage shutdown, prior to ignition of the second-stage engine. An insulating hat will cover the first-stage lox-tank dome, and a plastic insulation material will cover the exposed plumbing.

An analytic study of temperatures and pressures in the interstage structure has substantiated the initial design approach. A dummy interstage structure has been constructed for tests by Aerojet General to determine temperature and impingement pressure during a simulated first-stage separation employing a firing second-stage engine. This structure is of "battleship" design and will be used to establish critical conditions; two mockups similar to production interstage structures will then be used for tests at critical conditions. Physical separation will not be attempted. Meetings have been held with Aerojet General to resolve instrumentation and recording requirements for these tests. The most important purpose of the impingement tests is to substantiate the assumption that no collision will occur between stages during first-stage separation; this assumption is predicated on an impingement force on the first stage equal to 50 percent of the second-stage thrust.

Consideration of vehicle structural loading as a result of first-stage engine deflection has resulted in an increase in thickness of the first-stage fuel tankage material from .050 inch to .063 inch, and an increase in the structural strength of the second-stage controls compartment. The resultant weight increases are 22 pounds in the first stage and 4 pounds in the second.

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\*P. V. R. No. 9, p. 8

The current weight status of the launching vehicle reflects the increase in first- and second-stage weights due to the above design considerations:

Stage	Specification Weight (lb)	Target Weight (lb)	Current Weight (lb)
First	1782	1565	1476.7
Second	973	865	913
Third	89	89	78.1

The supersonic windtunnel tests at NAMTC, Point Mugu, California, were completed 21 September.\* Force and pressure data were collected in the range of Mach 1.6 to Mach 3.5. Preliminary examination of the data indicates only small deviations from previously computed theoretical values which have been used for supersonic aero-coefficients. Further analyses will be made following the receipt of smoothed data from NAMTC.

Arrangements for the use of the WADC 10-foot transonic windtunnel have been completed and models have been shipped to Wright Field. Tests\* are scheduled for 30-31 October 1956.

The most practicable method of obviating the effects of the Von Karman vortex-shedding phenomenon† appears to be the installation of spoilers on the vehicle over the length of the second stage. These spoilers would be designed with sufficient flexibility to prevent loading of the vehicle in the presence of high ground winds. They would be attached to the vehicle by means of an adhesive which would permit separation of the spoilers shortly after the vehicle is launched. Spoiler materials and adhesives are being investigated.

The controls design has been completed for TV-1 and TV-2 and will be completed for TV-3 by the end of October. The instrumentation lists for all vehicles are being received. Unresolved items of measurement are gyro vibration, propellant flow rate, and angle of attack.

Most of the qualification tests on the Yardney 20 HR-20 Silvercel battery, for use as flight power on TV-2 and up, have been completed. The results of these tests are considered satisfactory. Completion of the test qualification program as scheduled is dependent upon the delivery of suitable shock and vibration equipment.

The primary source of ac power for TV-3 and subsequent vehicles is a rotary inverter. Tests and modification of three different types of inverters are now in progress. Modification of this unit to minimize its frequency and voltage modulation is being studied in accordance with requirements of the vehicle controls equipment.

## PROPULSION

### First Stage

The initial phases of first-stage propulsion development testing have been completed with the test series of 8 runs on demonstrator engine no. 3 (a flyable prototype). All designs are considered fixed at this time, i.e., no major configuration changes anticipated.

\*P.V.R. No. 9, p. 3

†P.V.R. No. 5, p. 3; and No. 9, p. 3

A preliminary draft of the first-stage engine handbook has been completed and no delivery delays are anticipated. Also the documents "Summary of Design Consideration," "Summary Status Report," "Engine Component Weight and Center-of-Gravity Report," and "List of non-An or MIL electrical parts" were prepared by GE for delivery to GLM in accordance with the GLM 924 specification.

The first deliverable production engine (P-1) has been mounted in Malta Test Station pit 25 and test-fired five times without mishap. The first three runs were checkout runs of 50-second duration for the purpose of adjusting all variables prior to acceptance testing. The motor was then fired twice, for approximately 150 seconds each time, to comply with the acceptance test requirements. The specific impulse data obtained from these runs were found to be low. Other pertinent data were within specifications. The average values of specific impulse were 249.5 seconds and 267 seconds, respectively. A second calibration on the test pit instrumentation is being made to substantiate the accuracy of the initial calibration; it is hoped that this new calibration will improve the reduced engine data. Meanwhile, the P-1 engine has been packaged and delivered to GLM. The second production engine (P-2) has been assembled and is ready to be mounted in pit 25 for its acceptance testing.

Tests of a modified injector in pit 3 are currently being made to determine whether or not the injector heat transfer can be improved.

In April 1956, NRL Memorandum Report No. 582 was published with the title "A Method of Improving the Performance of the Vanguard First-Stage Powerplant by Adding Fluorine to the Liquid Oxygen Oxidizer." This report showed that the addition of modest amount of fluorine (15 to 21 percent by weight) to the liquid oxygen of the first stage might materially improve the overall vehicle performance. The gain results from (1) the increase in density-impulse or mass ratio obtained with the denser fluorine, and (2) the higher specific impulse which accrues with this more energetic oxidizer. This greater impulse results from an increase in the exhaust velocity which in turn results from a greater heat of decomposition.

The data in this report have been discussed with the NACA, Lewis Laboratory Propulsion Laboratory and with the General Electric Co. It was agreed (1) that the data were valid and that an increase of about 800 fps could indeed be obtained with a 20-percent  $F_2$ -lox mixture, and (2) that the problems of pump seals and materials would have to be solved; previous tests by Rocketdyne Division of North American Aircraft and the NACA showed that various plastics and metals are corroded by  $F_2$ . Since the corrosion rates of 20-percent  $F_2$  were not known, GE felt that a materials test program should precede any anticipated full-scale engine tests in the event that it should be decided to undertake an improvement program with GE.

A summary of the expected improvement gain is given in the following table for 20-percent  $F_2$ , 80-percent  $O_2$ , with RPI Kerosene as the fuel. Constant thrust is assumed.

Oxidizer	Vacuum Specific Impulse	Specific Gravity	Vehicle Mass Ratio	Burnout Velocity Gain
Lox	254 sec	1.14	0.6804	—
$F_2$ -Lox	267 sec est	1.23	0.6906	800 ft/sec est

During June and July several meetings were held with NACA and GE to define a possible improvement program and work schedule; GE was asked to submit a proposal, and NACA was asked to participate. The following schedule was established:

**NACA.** Small-scale ("miniature" X-405) 5000-lb thrust chamber tests would be conducted with hardware proportionately scaled down from the GE X-405 engine and supplied by GE. A four-month program was planned which would define heat-rejection data, specific impulses, and combustion efficiencies;  $F_2$  data from other facilities would be coordinated also.

**GE.** This facility would undertake a three-phase program consisting of:

- (A) seal and material tests under static-pressure and flow conditions,
- (B) short-duration full-scale X-405 engine tests, and
- (C) full-duration X-405 qualification tests.

The GE proposal for Part A only was accepted and NACA's participation was approved, during this report period; a contract was signed with GE on 18 July 1956. Parts B and C are predicated on success of Part A and have not been committed. In all of the above work, 20-percent was fixed as the optimum  $F_2$  addition, considering the criteria of  $F_2$  availability, toxicity and corrosion. The availability of liquid and gaseous  $F_2$  has not been considered a serious problem; however, the scheduling of a liquid  $F_2$  road trailer and mixing valve remains to be arranged. Toxicity and handling hazards associated with  $F_2$  are being studied; the experiences of other facilities will be considered.

The GE Company has begun static no-flow tests of various pump- and valve-sealing materials in a homogeneous mixture of 20-percent  $F_2$  -lox. (For fluid mechanical purposes this mixture can be considered a perfect liquid.) The two most critical materials, Teflon and Graphitar, stood up satisfactorily with little evidence of corrosion. However the next series of tests, with the  $F_2$  -lox mixture flowing over and past the sealing materials, will be more severe and will show more clearly which material is compatible with the mixture.

#### Second Stage

During this report period Aerojet General continued firing tests on three injectors: a 72-pair impinging showerhead, a 120-pair impinging showerhead, and a non-impinging showerhead. The 72-pair injector head has been chosen for the time being as the production item. It has been reported to deliver a characteristic exhaust velocity of about 5000 fps at rated mixture ratio. The 120-pair injector yields about 4900 fps at rated mixture ratio and about 5100 fps at an off-mixture ratio; it is not currently considered a production item but will be kept as a backup, and some work is continuing to improve its mixture-ratio characteristics. The non-impinging injector has a characteristic exhaust velocity of better than 5100 fps yielding above 278 sec of specific impulse at altitude. However, this injector has not been tried with a Vanguard thrust chamber, as have the other two. The heat-flux characteristics of this injector are expected to be about 4 btu per square inch per second at rated mixture ratio. Aerojet now expects that this heat-flux rate will not result in an untenable bulk temperature rise of the coolant. The non-impinging injector also is considered a backup item.

Several successful non-burnout full-duration (140-second) firings were conducted during this report period, with the aluminum spaghetti thrust chamber (Fig. 2). Most of these tests

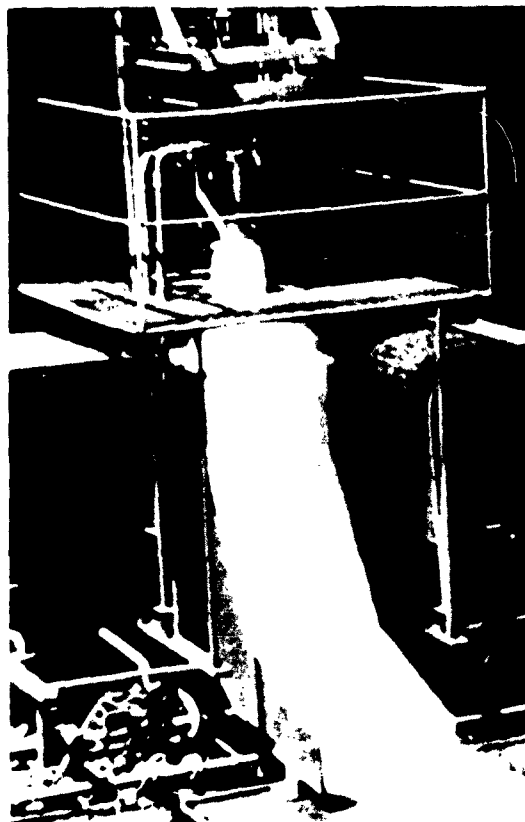


Fig. 2 - Test firing of Vanguard second-stage engine (Aerojet photo)

were made with a sea-level nozzle. The first firing, however, was conducted with a complete thrust chamber i.e., with a fully expanded altitude nozzle. A severe vibration of the nozzle was noted during the first few seconds of firing, and the firing was terminated. This vibration is believed to have been an "oilcan" effect of the very thin nozzle, caused by the over-expansion of the nozzle and the decrease of pressure near the outer periphery of the exit cone. This decrease of pressure caused the external atmospheric pressure to deform the fragile cone.

Aerojet will use the value of 1.75 for the second-stage thrust coefficient.\* On the basis of data from another development, this is conservative and should result in the desired specific impulse at altitude. It now appears that the second-stage engine assembly can be delivered on schedule.

While thrust chamber fabrication progress has been satisfactory and full-duration firings have been obtained, the tankage used for these tests has been prototype heavy tankage. Aerojet has subcontracted the lightweight 410 stainless-steel tankage, and the contractor is having difficulties. Several cases of weld fatigue and cracking were noted during

\*The thrust coefficient is a measure of the augmentation of the thrust due to the nozzle configuration.

hydrostatic tests of the tank, and in one case a welded boss was severed when subjected to pressure. When recently a tank was finally assembled and welded, the heat-treating facilities broke down, as well as the annealing facilities. The entire province of annealing, heat treating, and stress relieving is a very complicated one for tanks of this size, with so little working material. At this writing, no successful tank has been assembled and fired with the lightweight thrust chamber. However, Aerojet is building its own tank system against the possibility of the subcontractor failing to deliver. Aerojet hopes to have a tank ready before the end of the third week of October, but a very sustained effort will be required to produce a complete tank assembly, proof-tested and fire-tested, by that time. All valves, accumulators and regulators for this program have been cycled and proof-tested several times. The helium pressurization with the restricted-grain solid charge has also worked well and has shown no undue pressure peaks during the pressurization cycle.

### Third Stage

#### Allegany Ballistics Laboratory

During this report period the Allegany Ballistics Laboratory has made progress in the use of the fiberglass case and the development of an igniter. Two additional firings have been made, utilizing fiberglass cases. Both cases burned through at 29 seconds of burning because of inadequate insulation around the propellant slotted section. An insulating material has been formulated at NRL in an effort to solve this problem. Initial tests indicate this material will insure proper insulation.

Tests have been conducted incorporating the igniter in the resonance suppressor with success. Better ignition characteristics have been developed with a mixture of boron pellets and potassium nitrate. Tests with the igniter under vacuum conditions are scheduled.

Problems of supply of the plastic liners to be incorporated with the nozzle carbon insert and the fiberglass expansion cone have arisen as a result of fabrication difficulties encountered by the Cincinnati Testing and Research Laboratories. (The liner is sent to the Young Development Laboratories for incorporation of the fiberglass expansion cone.) An additional delay was encountered by the National Carbon Company, which supplies the graphite pieces for the nozzle throat section. These problems have been resolved but have delayed the prequalification test schedule. Initial prequalification tests will be made with a steel expansion cone fabricated by ABL.

The Solar Aircraft Company and the Hicks Company, who are supplying the steel cases to be used as a backup for the fiberglass cases, have furnished ABL with two steel cases for initial testing. The completion of the twenty cases on order is now scheduled for 10 November. The fiberglass aft-end closure will be incorporated with the steel case. Further testing now indicates that ABL will be able to obtain a specific impulse of 254 seconds at altitude.

Because of difficulty in the procurement of auxiliary parts by the subcontractors, the prequalification test schedule has been delayed. It is expected that this phase of the program, originally scheduled for completion on 1 November, will be completed by about 20 November.

### Grand Central Rocket Company

The Grand Central Rocket Company has continued testing lightweight steel cases with various propellant configurations in order to overcome propellant cracking and progressive burning. Burning resonance was indicated on some firings. The propellant internal configuration has been extended the entire length of the case to the domed end of the chamber. More neutral thrust-time and pressure-time curves have been obtained, and propellant cracking at the 30° F conditioning temperature has been eliminated, but a loss in total impulse has resulted from the reduction in propellant content.

Two static tests have been made with another propellant, designated GCR 207. The initial results indicate that this propellant has a higher specific impulse than GCR 201C. A neutral thrust-time curve was indicated. Environmental tests are to be conducted to test its low-temperature properties, and further static tests will be required to substantiate the performance parameters.

GCR has been developing a propellant-type igniter for increased ignition flameability. This igniter has performed reasonably successfully at low pressures, and further development is planned to ascertain its possibilities as a vacuum igniter.

Because of the propellant problems and the low performance indicated by latest firing tests, GCR has extended the development phase and is now scheduled to start prequalification testing during the latter part of October, to be completed by about 20 November instead of the originally scheduled 31 October.

### FLIGHT CONTROL

Horizontal and vertical controls tests have been completed on TV-0 under simulated flight conditions.

### Guidance

#### Reference System

The reported\* prelaunch cooling air requirements for the reference system were premature. Tests at Minneapolis-Honeywell indicated that a flow of 40 cfm of 40° F air is excessive in that the gyro heater capacity is insufficient. Reduction of the airflow to 10 cfm and thermal isolation of the gyro cases are being considered. An alternative is to increase heater capacity, which might affect the scheduled delivery date of 1 November.

Gyro drift figures from single-frequency vibration tests were greater than those specified. The difficulty was attributed to unbalance of the vibration isolators. Matched isolators reduced the drift by a factor of three, and it now appears that specifications will be met. The prototype and first production units will be completed by 31 October; the electronic equipment is completed for unit no. 3.

#### Attitude Control

Tests of the breadboard magnetic amplifier for the Vickers autopilot have continued on the first-stage dynamic controls mockup with simulation of the vehicle dynamics by the

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\*P. V. R. No. 9, p. 7



REAC. Instability of the overall system was evident as a low-frequency oscillation. Investigation disclosed that the recent addition of a lag circuit to the hydraulic servo feedback path\* was the contributing factor. Reduction of the capacitance eliminated the oscillation.

Examination of the jet attitude systems disclosed excessive time delay in relay pickup and dropout. The inductive loading of the relay on the magnetic amplifier delayed the current buildup, with the result that the ratio of jet on-time to off-time was such that an exorbitant amount of propane would be required. Shunting the relay coil with a capacitor and substituting a fast-acting relay produced a static response slightly below that specified. Dynamic operation of the system, however, has shown degraded performance with extremely high fuel demand. The cause of this inferior performance has not yet been determined.

Serious delay in Vickers' program has resulted from their being unable to obtain Tantalytic capacitors. The first unit is undergoing qualification testing and will be delivered on 31 October. The first production unit will be shipped 11 November along with the test equipment for the Glenn L. Martin Co., and the field test equipment.

The status of the backup subminiature electronic amplifier is satisfactory. Tests of this amplifier have shown none of the deficiencies observed in the magnetic amplifier. The weight and volume of these units are comparable; the only weight penalty which would be incurred if the electronic amplifier were used would result from the addition of a dynamotor supply. In the event that the difficulties experienced with the magnetic amplifier are not overcome, the electronic amplifier will be flown.

Studies have shown that the steady-state first-stage engine deflection in the presence of specification wind profile† is a maximum of 2.33 degrees in either the pitch or the yaw plane; this includes a deflection of 0.87 degree for controls stabilization in the presence of winds (95-knot profile plus 23-knot gusts), a center of gravity offset of 0.05 degree and thrust misalignment and displacement of 0.41 degree.

Studies of structural loading of the vehicle by first-stage engine deflection indicate that a maximum resultant deflection of 4.5 degree is acceptable. This will require mechanical stops to limit engine deflection in the event that pitch and yaw deflection components both exceed 3.2 degrees.

The study to determine the maximum allowable wind profile is continuing. The allowable wind velocity at any time in the trajectory is limited by either of two structural considerations:

1. Buckling failure in the propellant tanks resulting from the engine deflection needed to balance the wind-disturbance pitching moment.
2. Failure of the second-stage instrument section due to the angle of attack resulting from winds.

A plot of associated maximum allowable loads versus time is being determined, and a limiting wind profile is being constructed. Since it is expected that the most critical wind condition will be experienced during transonic flight, the scheduled transonic windtunnel tests at WADC‡ take on greater significance. The values now being used for transonic aero-coefficients are nearly all developed from theoretical analysis and have little support from actual windtunnel data.

The pneumatic actuator for first-stage roll control has been completed. This item, designed by GLM, utilizes helium to swivel the roll nozzles in the turbopump exhaust lines. The measured response of the unit was satisfactory, and installation has been made in the dynamic controls mockup.

\* P. V. R. No. 9, p. 7

† P. V. R. No. 9, p. 8

‡ P. V. R. No. 9, p. 3

### Flight Program and Staging

The mechanical layout of the programmer is complete, as is the circuit design for the relays and power amplifier. Delivery of two units is scheduled for 15 November. The mechanical vibration tests which were initially planned are complete, but further tests will be made with the circuits energized, after degaussing coils have been procured for the vibration machine.

A flight-time computer (for determining the time of third-stage launch) is scheduled for delivery on 31 December. The integrating accelerometers for these units have not yet been delivered to Air Associates.

The following tests in regard to staging are now in progress or scheduled for completion before the end of the year:

1. A test to determine the effect of separating current-carrying electrical connectors, under extremely low atmospheric pressures.
2. A test to determine the time lag which occurs in the firing of explosive bolts.
3. A test to check the operation of electrical circuitry and components for separation of the first and second stages.

A revised relationship between the second-stage burnout velocity and the time to fire the third stage has been requested as a result of a possible trajectory modification for a projection altitude of 400 miles. This revision necessitates a gearing change in the time computer, re-scaling of torquer current values in the reference system, and new values of programmer pitchover initiation times.

The Atlantic Research Corporation has rejected the metal parts supplied by the subcontractor to be used during qualification testing of the spin and retro rockets, and have bound a new subcontractor. ARC has been manufacturing lightweight metal parts in their own shop to bridge the delay associated with the change in subcontractors so that there will be no delay in the qualification testing. A test has been made utilizing a spin table loaded to simulate the third-stage mass, and third-stage spinup was satisfactorily simulated. Work is also progressing on the insulating cover sections for the retro-rockets. These sections are being designed to withstand the aerodynamic heating during second-stage flight prior to separation of the second and third stages. Simulated heating tests are planned during the month of October. Further development work will also include testing of the nozzle cone cover to determine whether or not deflection during expulsion of the cover when the retro rocket is fired might impair the jet reaction. This work is scheduled for completion in November.

### GROUND EQUIPMENT

Observation of electrical installations at the launching complex as of 1 October, indicated that light and utility wiring in the blockhouse and equipment house is about 50 percent complete. The laying of all cable in the concrete trench between the equipment house and the blockhouse is complete. All junction boxes and 50 percent of the terminal panels are installed. In addition, the installation of overhead cable racks in the equipment house and the blockhouse is virtually complete. The remaining electrical equipment and hardware is scheduled to be shipped from the GLM plant on 15 October. Delivery of the dc ground power supply for installation in the equipment house is scheduled for 1 November.

All technical problems of the test equipment being developed by Polorad have been cleared up; however, there has been some delay in procurement of certain purchased items. Delivery is scheduled for 1 December.

Minneapolis-Honeywell has shipped the first blockhouse controls monitor unit and the second unit is completed. Units 3 and up are being wired. Tester console no. 1 has been shipped; no. 2 is completed. Reworking of adapter for the dividing head (gyro calibrator) has been required and delivery is scheduled for 1 November.

### THE SATELLITE

#### CONFIGURATION AND DESIGN

Destruct tests have been scheduled for both the 20-inch and the 6-inch satellites for the purpose of evaluating their structural designs.

Because of thermal considerations and to facilitate handling and reduce corrosion, it has been decided to gold-plate all magnesium parts of both satellite types.

The dynamics balancing equipment\* is now ready for use at NRL. The balancing will be done at 336 rpm, which is the resonant frequency for the pickups and provides maximum sensitivity. Preliminary balancing attempts indicate that the specified limits can be met satisfactorily.

#### 20-Inch Satellite

A partially assembled aluminum model of the 20-inch satellite is shown in Figs. 3 and 4, and a fully assembled model with folded antennas is shown in Fig. 5. The following structural tests have been completed on this aluminum model with no failures of any kind:

1. Steady-stage acceleration to 55 g
2. Several vibration tests in three axes to an average of 12 g
3. Vibration in the horizontal plane (perpendicular to the rocket axis) to an average of 26g<sup>†</sup> from 35 cps through 2000 cps (duration 10 min)
4. Rotation at 300 rpm (with antennas pinned) about the vertical axis
5. Pressure zones tested to 35 psig at 300° F and to less than 1 mm Hg at room temperatures.

\*P. V. R. No. 9, p. 13

<sup>†</sup>limit of testing machine



Fig. 3 - Oblique view of partially assembled 20-inch satellite

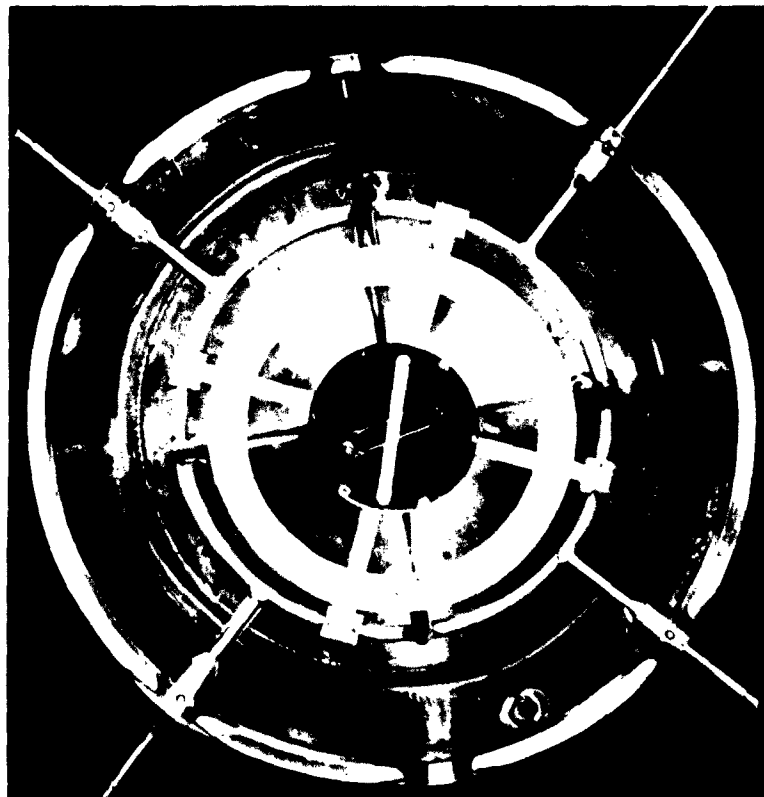


Fig. 4 - Top view of partially assembled 20-inch satellite

The original and current weights of the various components of this satellite (in magnesium) are given in Table 1.

**TABLE 1**  
Breakdown of Estimated Weights for the 20-inch Satellite

Component	Current Weight (lb)	Original Estimate* (lbs)	Δ Weight (lbs)
<b>MINITRACK SYSTEM</b>			
Antennas	0.62		
Batteries	5.20		
Electronics	0.25		
Total	6.07	4.0	+2.07
<b>LYMAN ALPHA EXPERIMENT</b>			
Electronics & Detectors	0.25		
Batteries	0.25		
Skin Attachments	0.20		
Peak Reader	0.25		
Total	0.95	1.00	-0.05
<b>TELEMETERING</b>			
Coding System	0.25		
Orbital Peak Memory Unit	0.13		
Magnetic Event Counter	0.25		
Meteor Collision Detector	0.25		
Batteries	0.20		
Total	1.08	4.0	-2.92
<b>WIRING AND MISCELLANEOUS</b>			
	1.00	1.00	—
<b>ENVIRONMENTAL EXPERIMENTS</b>			
Pressure Zones	2.32		
Pressure Gage & Connections	.13		
Erosion Test Device	.10		
Total	2.55	1.00	+1.55
<b>SEPARATION DEVICE</b>			
	1.00	1.00	—
<b>STRUCTURE</b>			
Internal Structure	1.10		
Shell	2.00		
Internal Package, Supports, 4 Heat Switches	2.50		
Total	5.60	9.5	-3.9
<b>COMPLETE SATELLITE</b>			
	18.25	21.5	-3.25

\* As of 5 May 1956



Fig. 5 - Fully assembled 20-inch satellite with antennas folded

#### 6-Inch Satellite

Two 6-inch satellite structures in magnesium have been received and two more are scheduled for receipt on 15 October. The first two are being assembled for final structural tests, and the other two will be coated and assembled for thermal tests. The following tests have been completed on aluminum models of this design with no failures of any kind:

1. Steady-state acceleration to 68 g
2. Several vibration tests in three axes to an average of 12 g
3. Static load of 89.6 lb on vertical "Kel-F" supports after keeping shell temperature at 300° F for 6 min 35 sec.

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### Antennas

The following tests have been completed on the spring-actuated antennas with no failures of any kind:

1. Steady-state acceleration along vertical axis
  - a. mounted on 20-inch satellite, to 55 g
  - b. mounted on 6-inch satellite, to 68 g
2. Vibration - antennas were mounted on satellites during all satellite vibration tests listed above
3. Static load at c.g. of 7 lb (equivalent to approx. 100 g) at room temperature
4. Static load at c.g. of 4.9 lb at temperatures up to 300°F with Teflon inserts\* attached
5. Static load at c.g. of 3.25 lb at temperatures up to 460°F with Teflon inserts attached
6. Mechanical cycling (erection) of four antennas, 100 cycles each.

### Separation Mechanism

Successful operation of the satellite separation mechanism has been witnessed at the Raymond Engineering Laboratory (REL). The preliminary operational evaluation of this device is that it will perform the required functions satisfactorily and reliably. The weight of the present model is 1.25 lb, which is 0.5 lb in excess of the target weight; however, there are numerous ways in which the weight can be reduced, and REL will make every effort to deliver two lighter models to NRL on 1 November for testing and evaluation.

### Heat Switch

Models of the heat switch for the 20-inch satellite, an NRL-designed heat switch for the 6-inch satellite, and a Fenwall Corporation heat switch for the 6-inch satellite are ready for evaluation tests. These tests are scheduled to start in the week of 15 October.

### ENVIRONMENTAL TESTING

The satellite environmental chamber installation is complete. The lowest pressure obtained so far with the new pumps is 5 microns of mercury, but it is believed that the gage line was leaking. Further adjustment, with the aid of a vacuum technician, should result in the desired pressure of 1 micron.

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\* P.V.R. No. 9, pp 13-14

A 6-kw amplifier has been received and put into operation with the sinusoidal vibration test equipment. A new attachment to this equipment has produced a better lateral vibration test of a satellite. A second vibration table is being ordered to serve as a standby against failure of the present table, and to allow preliminary tests of components while the present table is in use.

A helium gas gun is being checked out for use in simulating meteor impacts;\* a primary missile velocity of 15,000 fps has been obtained. The gun is being fired in a range evacuated to 50 microns.

### INSTRUMENTATION

A study has been undertaken to reallocate the satellite telemetry information channels for more efficient utilization of the available bandwidth. No variation is expected in the information from the environmental experiments during the short readout interval; the Lyman-alpha experiment, however, will encompass a bandwidth of at least 10 times the satellite spin frequency. Therefore, the Lyman-alpha instantaneous and solar-aspect signals will be telemetered for at least two thirds of the time, and the environmental experiments for the remaining one third.

The telemetry coding system has been miniaturized and printed-circuit techniques have minimized the weight of the card. The first prototype model weighed 2.3 ounces without potting, including 43 transistors for a basic 24-channel system. The channel reallocations may result in a slight revision of this figure.

A program is underway to test the components of the coding system. The purpose of the first test will be to measure the electrical characteristics of the various types of transistors and to insure that acceleration and vibration will have no permanent effects upon these characteristics. These tests will be carried out with the same transistor mountings and potting as are used on the printed-circuit card.

Printed-circuit layouts of the meteor collision detector are underway.

A flight model of the Lyman-alpha equipment has been constructed, and preliminary stability testing of the circuit has been completed. Specifications have been prepared on the ultraviolet photoionization chambers for the Lyman-alpha experiments, and contract negotiations have started for construction of these chambers.

The National Semiconductor Products Company is now manufacturing a solar cell, with two separate outputs, in a type S1 case. Since the output of the solar cell will be affected by temperature variations, a study is underway to learn the magnitude of the effect and so that it may be compensated for if necessary.

Ground recording and test procedures are now being formulated and all operational and test facilities are being integrated. The photographic data readout equipment is very nearly complete, and testing will begin immediately upon completion.

The design of a linear detector for the ground station receivers has been completed, and prototypes are under construction at the NRL model shop.

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\*P.V.R. No. 5, p. 17



### THEORY AND ANALYSIS

Skin temperatures have been calculated for the TV-0 re-entry nose cone experiment in order to determine the manner in which the instruments will be used. The appropriate information has been forwarded to AFMTC.

A theoretical study has been completed by GLM on the third-stage separation problem. The inner diameter at the forward end of the second stage, which was increased from 26 inches to 32 inches,\* is now expected to provide adequate clearance. A full-scale mockup of the second and third stages has been constructed for the purpose of simulating the separation conditions.

The fraction of time per orbit during which the satellite will be illuminated by the sun has been determined for several representative sets of orbital conditions.

### ELECTRONIC INSTRUMENTATION

#### TELEMETERING

##### PPM/AM Systems

One ppm/am ground station and three monitor racks have been completed by the Elsin Electronics Company and shipped to NRL, which in turn has shipped them to AFMTC. This delivery completes the Elsin contract.

The ppm/am trailer at AFMTC is in operating condition except for the 3-element antenna. The ppm/am trailer at Grand Bahama Island is in operating condition except for the receiver, which is being repaired.

##### PWM/FM Systems

The pwm trailer at AFMTC is in operating condition except for the 3-element antenna; one radiated test has been recorded.

##### FM/FM Systems

One fm/fm vehicle telemetering transmitter has been received from the Hoover Electronics Company. This transmitter has been checked out and shipped to GLM for TV-1.

#### VEHICLE TRACKING

Delivery of the first AN/DPN-48(XE-1) S-band radar beacon,† scheduled for 20 September, has been delayed because of technical difficulties. It had been planned to use this beacon in TV-1, but it will now be necessary to use the modified AN/APN-19 instead.

\*P.V.R. No. 8, p. 2; and No. 9, p. 2

†P.V.R. No. 9, p. 16

One AN/DPN-31 C-band beacon has been received from the Hazeltine Electronics Company and will be used in the first stage of TV-1.

Six DOVAP transponders have been promised for delivery from BRL on 19 October.

A request has been submitted to have the DOVAP test signal generator at AFMTC calibrated by RCA to determine that the frequency is sufficiently accurate for Vanguard test purposes.

#### RANGE SAFETY

A contract has been awarded the Connecticut Telephone and Electric Company for the production of AN/ARW-59 range safety command receivers for the satellite launch vehicles (SLV's). Specifications are nearly complete for a transistorized decoder to replace the KY-55/ARW decoder now used with the ARW-59.

### THE MINITRACK SYSTEM

#### TRANSMITTER UNITS

Vibration tests on the Western Electric Type GA 53233 transistor show encouraging results. In an operating test on a transistor with the serial number 851, there was no measurable frequency modulation or amplitude modulation of the cw output due to the mechanical vibration of the transistor at levels up to 12 g in the frequency range from 20 to 2000 cps. A later test of 12 transistors was run to the same levels and frequencies; two transistors failed to survive the test but ten units had no measurable change in rf characteristics after the vibration.

#### TV-0 PREPARATIONS

The Minitrack preparations for TV-0 are complete. A cw transmitter with a power output of 100 milliwatts will be flown in a 6-inch sphere which will be ejected at 120 seconds by a powder-actuated spring-operated device. The antenna system will be a 4-element turnstile using spring steel tapes for the radiators. The installation will be mounted on the North side of the vehicle between the tanks. The ground-station phase measurement will be made with the Mark II Minitrack System to be located on the Telemetry Pad at Cape Canaveral. Two complete Mark II systems, i.e., 4 receiver units and 2 local oscillator units, have been constructed. The necessary equipment for one complete field station has been checked out and will be installed in the trailer this week preparatory to shipment to Cape Canaveral for TV-0.

#### BLOSSOM POINT TEST FACILITY

The Blossom Point Minitrack Test Facility is now a complete angle tracking station. The transmission lines have all been installed and preparations are under way for filling the ditches with sand and seeding the field. All antennas have been checked with regard to impedance match and antenna pattern, and no discrepancies have been found. Many airplane flights have been made and the recent flights have shown that the correlation

between optical and radio tracking is as good as the limits of the optical tracking data will permit ( $\pm 0.1$  degree). The house is complete and is now in use.

The 5-rack prototype Minitrack ground station unit is being modified to eliminate one rack, in accord with changes made in the Bendix contract. This change was brought about by the decision to eliminate magnetic-tape backup recording, thus allowing a combination of the phase-measurement rack and its power supply rack. In addition, the time-standard rack is being modified to include serial time-coding readout every six seconds instead of every minute, and emergency power transfer in case of failure of primary power. These changes are being made so that the prototype unit will be electronically identical to the units to be supplied by Bendix; thus the field crews can be trained on equipment similar to that which they will use in the field. The new time-standard rack is scheduled for installation at Blossom Point by 1 November, and the new phase-measurement rack by 15 November.

#### TELEMETERING GROUND STATIONS

Specifications for Minitrack telemetry receiver racks have been completed and submitted for the procurement of 10 units. These units together with the magnetic recorder units, signal amplifiers and monitor oscilloscopes, which are being supplied by the Applications Branch, comprise the complete electronic receiving portion of a telemetering ground station. In addition to these receiving units, two turn-on transmitters are being provided for use with those satellites which require that the scientific equipment and the telemetering transmitter be turned on as the satellite passes within range of a ground station. These turn-on transmitters are to be in "ready" condition at the time of passage, one unit supplying backup for the other; no other spare units are to be supplied. The initial units are presently scheduled for delivery by mid April 1957, and the final units on 15 May 1957.

The antennas for the telemetering ground stations have been designed as dual units including both the turn-on transmitting antenna and the receiving antenna. Because of a possible need to increase the gain of this receiving antenna, a modification of the antenna is now being considered. The information regarding such a change will be complete by 23 October, on which date a meeting with the Corps of Engineers is being held to solidify all station site criteria and plans.

#### CALIBRATION

Agreement has been made with the Bendix Radio Division for modification of the 108-Mc calibration signal chassis to provide a more satisfactory attenuator having continuous control over an extended attenuation range. Permission for this change was necessary to avoid upsetting the scheduled delivery date. Sample units of this chassis are now complete and will be supplied to Bendix by 19 October.

## DATA PROCESSING

### TELEMETERED DATA

The contract for the automatic recording and reduction facility for telemetered data has been executed by Radiation, Incorporated, and by the Navy; the effective date of the contract is 23 July 1956. Radiation, Inc. is in the process of scheduling production and ordering equipment for all parts of the system which are standard items. Development of other parts of the system is continuing both at the company and at NRL.

### ORBITAL DATA

The International Business Machines Corporation has leased a building for the Vanguard computing center at 615 Pennsylvania Avenue, N. W., Washington, D. C. The building will be remodeled for installation of an IBM 704 computer and auxiliary equipment in the Spring of 1957.

The Fourier series addition and multiplication subroutines have been used for sample computations; improvement of these subroutines is being undertaken. A first draft of the subroutine for elliptic orbit computations from three initial observations has been written by IBM mathematicians.

### SECOND-STAGE APOGEE PREDICTION

NRL is continuing to work closely with the Glenn L. Martin Company, RCA (Moorestown, N. J.), and AFMTC (and its contractors and subcontractors) to complete detailed plans for the third-stage firing system by ground command. It is planned to have this system ready for operation with TV-3 and subsequent vehicles. This firing system, including the radar and computing equipment to be used, has been described briefly in two previous reports.\*

## PLANNING AND SCHEDULES

The Master Planning Office is proceeding with the preparation of the master plan for Project Vanguard. In this connection, charts of the following subjects have been prepared in a semifinal form and have been reviewed by the responsible codes.

1. Principal Electronic Ground Equipment at AFMTC to Support Flight Operations.
2. Facilities and Installations at AFMTC to Support Flight Operations.
3. Data Acquisition and Processing.
4. Minitrack Stations.

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\* P. V. R. No. 8, p. 16; and No. 9, p. 18

Charts of the following subjects are now being prepared for the review of the various codes and will be distributed for their comments in the near future:

1. Physical Data on Test Vehicles and Satellite Launching Vehicles.
2. Major vehicle electronic flight instrumentation and controls.
3. Principal vehicle tests and operations conducted by NRL and GLM personnel at Cape Canaveral.
4. Vanguard field organization and procedures at AFMTC.
5. Vanguard NRL science program organization and functions.
6. Trajectory Data, vehicle electronic equipment, and AFMTC range stations and ground equipment used during each test flight and satellite launching flight.

Schedule charts showing the scheduled, promised, and actual delivery dates of major items of equipment and vehicle components are being maintained. These charts indicate the overall status of the program and the effect of any slippages on the project.

\* \* \*

<p>Naval Research Laboratory. Report 4860 (CONF.) PROJECT VANGUARD REPORT NO. 10 - PROGRESS THROUGH OCTOBER 15, 1956 (Unclassified Title), by Project Vanguard Staff, 22 pp. and figs., November 4, 1956.</p>	<p>1. Satellite vehicles -   Launching</p> <p>2. Satellite vehicles -   Research</p> <p>3. Rockets -   Development</p> <p>1. Project Vanguard</p>
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